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BEHAVIORAL AND PSYCHOLOGICAL CORRELATES OF FLUCTUATING ASYMMETRY: A WITHIN-FAMILIES STUDY

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by

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Dedication

Dedicated to the memory of Lee Willerman.

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Behavioral and Psychological Correlates of Fluctuating Asymmetry: A Within-Families Study

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Numerous studies have shown fluctuating asymmetry (FA), a physical manifestation of developmental instability, to be associated with a range of physical, behavioral and psychological traits in humans. Reported associations between FA and psychometric intelligence and social dominance were investigated using a within-families design. Methodological improvements in the measurement of FA using four repeated observations of each physical trait and using high-resolution photocopies of the traits rather than direct measurement were also implemented, resulting in an alpha reliability for FA of .89. Primary analyses involving 42 pairs of adult brothers found a statistically significant between-family correlation of -.32 between FA and intelligence test scores but no statistically significant correlation within-families. No statistically significant correlations were found between FA and social dominance. The results were interpreted as indicating that cross-assortative mating for FA and intelligence is responsible for the observed association between these variables in the general population. These results were not surprising in light of previous research with respect to mate preferences and mate choices. Implications for social stratification along an array of desirable traits were discussed, as were methodological considerations for future research involving mating and reproductively relevant traits.

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INTRODUCTION

During the past decade numerous studies concerning human developmental instability (DI), assessed through morphological fluctuating asymmetry (FA), have identified a growing number of behavioral and psychological covariates of FA (for reviews see Gangestad & Thornhill, 1997b; Kowner, 2001). Individual differences in FA are believed to result from a combination of differential exposure to developmentally disruptive events or environmental conditions and heritable individual differences in the capacity for stable (i.e., bilaterally symmetrical) development in spite of these challenges (Livshits & Kobylianski, 1991; Gangestad & Thornhill, 1997b; Moller & Swaddle 1997; Palmer & Strobeck 1986; Moller & Thornhill 1997). In both animal and human studies FA is primarily a male-associated phenomenon; most behavioral correlates of FA, in both males and females, are associated with FA in males of the species (Neville, 1976; Gangestad & Thornhill, 1997a; Moller & Pomiankowski, 1993). Most FA researchers cite sexual selection theory, either explicitly or implicitly, to explain this phenomenon (Watson & Thornhill, 1994; Moller & Pomiankowski, 1993). According to this application of the theory FA denotes relative quality of males, conferring advantages to low-FA males, the females with whom they mate, and their progeny. Females' preferences for high-quality (i.e., low-FA) males drive both directional selection for FA and evolved female mate-choices (Watson & Thornhill, 1994, Moller & Pomiankowski, 1993;

for a contrary view see Johnstone 1994).

FA is the degree to which an organism deviates from perfect bilateral symmetry on traits that are normally bilaterally symmetrical (Van Valen, 1962; Neville, 1976; Palmer & Strobeck, 1986; Livshits & Kobyliansky, 1991). Studies of non-human animals and humans have found that FA correlates with many traits and behaviors; commonly these are traits relating to reproduction, either directly or indirectly (e.g., Oakes & Barnard, 1994; Liggett, Harvey & Manning, 1993; Gangestad & Thornhill, 1997b). In one study, for example, male college students' FA correlated +. 42 with age at first sexual intercourse and -.32 with lifetime number of sexual partners (Thornhill & Gangestad, 1994). This finding is consistent with the animal FA literature; across many species, relatively symmetrical males have greater sexual and reproductive success than do relatively asymmetrical males (Watson & Thornhill, 1994). These differences in mating and reproductive success derive from two general processes: relatively more symmetrical males tend to fare better in direct competition with their relatively less symmetrical same-sex rivals (e.g., Thornhill, 1992a; Thornhill, 1992b), and they are more frequently selected as mates by females (e.g., Moller, 1990; Gangestad & Thornhill, 1997a).

Not all of the known correlates of FA are obviously related directly to reproduction, however. One study found FA to correlate with psychometric intelligence (negatively, -)(Furlow, Armijo-Prewitt, Gangestad & Thornhill, 1997). FA in human males has been found to covary with: ratings of attractiveness (-) (Alley 1993), violence proneness (-) (Furlow, Gangestad & Armijo Prewitt, 1998), body size (-) (Manning, 1995), masculinization of facial features (-) (Gangestad & Thornhill, 2003), metabolic rate (-) (Manning, Kourkouris & Brodie, 1997), sociosexual mating strategies (Simpson, Gangestad, Christensen & Leck, 1999), and social dominance (-) (Gangestad & Thornhill, 1997b).

While the list of known correlates of FA in human males has been enumerated and expanded, the causal explanations for these relationships have primarily been ontogenically focused (e.g., Kowner, 2001). Furlow et al. (1997) speculated about two possible explanations for the correlation they uncovered between FA and intelligence. They postulated that the relationship results either from developmental perturbations that affect both morphological and neurological development, or it arises from the reduced metabolic efficiency that is a result of developmental perturbations and the cause of reduced intellectual functioning. Both of these hypotheses imply that there is a fundamental biological-developmental relationship between FA and intelligence. However, there are other plausible explanations for correlated biological and behavioral traits, such as cross-assortative mating between the traits (Jensen, 1980). Fortunately, a research methodology exists for assessing the relative merits of causal explanations for correlated biological and psychological or behavioral traits: the within-family design (Jensen, 1980; Jensen & Sinha, 1993, Jensen; 1998; Nagoshi & Johnson, 1987; Cohn, Cohn & Jensen, 1988).

The within-family design allows comparisons of patterns of correlations between families (BF) and within families (WF). The patterns of BF and WF correlations will differ depending on the reasons two traits are correlated (Jensen, 1980; Jensen, 1998). The mere existence of a correlation between two traits in a sample of genetically unrelated individuals is uninformative with respect to the reason for the correlation. Unfortunately, with the one known exception of a study investigating ratings of attractiveness of monozygotic (MZ) twins (Mealey, Bridgstock and Townsend, 1999), none of the previously published studies of human FA utilized sibling controls. This is unfortunate because by examining patterns of correlations within families one may eliminate certain causal explanations for such relationships. For example, if the traits are intrinsically related, meaning they are both influenced by a common factor, the correlation will exist within sibling pairs, such that members of sibling pairs who score higher on trait X will tend also to score higher on trait Y. However, if the relationship is extrinsic - if it is due to social stratification for both traits, for example - the correlation within sibling pairs will be zero since the traits would segregate independently for each child in a family (Sutton, 1988). In this event, the correlation will be zero within families even though it may be high in the population, or between families (Jensen, 1998).

There is a particular refinement on the within-family design that would also be informative. For cases in which a statistically significant WF correlation is found, by also examining the correlation between traits within monozygotic (MZ) twin pairs, one may eliminate additional potential explanations for the causes of the correlation. For example, if the correlation between FA and intelligence is in fact due to intrinsic factors such as those proposed by Furlow et al. (1997), the correlation should obtain not only among sibling pairs, but also among MZ twin pairs since they are genetically identical but have different developmental histories. However, if the correlation is due exclusively to pleiotropy, meaning common genes condition both traits, the MZ twin correlation will be zero, since MZ twins have identical genotypes (Sutton, 1988; Willerman, 1979). In the case of pleiotropy among full- siblings or dizygotic (DZ) twins, who on average have just 50% of their genes in common, a WF correlation will exist (Cohn et al., 1987; Jensen & Sinha, 1993).

One other advantage of the use of MZ twins is that they enable computation of trait heritability estimates (Falconer, 1960; Willerman, 1979). Previously published heritability estimates for human FA have been based on suboptimal methodologies such as parent offspring regression analysis, which does not adequately isolate the effects of environmental and genetic contributions to observed parent-offspring relationships (Swaddle, 1997). Although other methods also point to a heritable component of FA (Moller & Thornhill 1997), more powerful methodologies such as twin studies would substantively add to the body of evidence for the heritability of FA (Willerman, 1979).

Although a substantial amount of research in human fluctuating asymmetry has been conducted in the past decade, a very substantial amount of non-human animal research on FA has been conducted over the past half-century, the result of which is an enormous body of literature on FA and its biological and behavioral concomitants (for reviews see e.g., Kowner, 2001; Moller and Pomiankowski, 1993).

Types of asymmetry

Fluctuating asymmetry, the degree to which an organism deviates from perfect bilateral symmetry on traits that are normally bilaterally symmetrical (Van Valen, 1962), is one of three defined measures of morphological asymmetry; the others are antisymmetry and directorial asymmetry (DA).

Antisymmetry

Antisymmetry exists when the two sides of a bilateral trait characteristically differ in size, but when there is no directional bias as to which side is larger in individual members of a population (Moller and Swaddle, 1997). The claws of the male fiddler crab, *Uca musica*, provide an example of antisymmetry. In this species there is a large size disparity in the c1aws; however determination of the directionality of this size asymmetry is a matter of chance. When one of a crab's two initially large claws is damaged and falls off, a much smaller claw will grow in its place (Neville, 1976). The arbitrary nature of this process is characteristic of antisymmetry, and is what distinguishes it from directional asymmetry.

Directional asymmetry (DA)

Directional asymmetry is similar to antisymmetry in that it is characterized by size asymmetry between halves of a bilateral trait. However, in DA one side of a bilateral trait reliably develops more fully than the other (Moller and Swaddle, 1997). Examples of structures exhibiting DA include mammalian hearts and brains, the eyes of flatfish, and the direction of coiling of snail shells (Moller and Swaddle, 1997).

Fluctuating asymmetry

Traits exhibiting fluctuating asymmetry have neither the predictable size asymmetries of antisymmetry nor the predictable directional biases of directional asymmetry. Rather, fluctuating asymmetry exists when a trait is, on average in the population, bilaterally symmetrical, but when the amount of deviation from perfect symmetry on these traits differs between members of a population, or between populations (Van Valen, 1962; Moller and Swaddle, 1997). There are several factors that have been identified as contributors to FA, both within and between populations, including genetic factors such as genetic variation, degree of protein heterozygosity, hybridization, directional selection and genetic mutations, and environmental factors such as temperature, nutrition, pollution, and stress (Livshits and Kobliansky, 1991; Moller and Swaddle, 1997; Kowner, 2001). Such factors generally are believed to affect the precision of phenotypic development, with variability in measured FA being the manifest result. In typical populations the degree of FA tends to be between one and two percent of absolute trait size (Gangestad and Thornhill, 1999).

Asymmetry and developmental instability (DI)

Typically, the observed differences in FA between individuals are attributed to latent individual differences in the ability to develop normally despite exposure to potentially disruptive events over the lifespan. This capacity or quality is variously designated developmental instability (or stability), developmental precision (or imprecision), and developmental homeostasis (Gangestad and Thornhill, 1997b; Moller and Swaddle, 1997; Livshits and Kobliansky, 1991). According to this theoretical model, over the course of development an organism is exposed to various environmental insults, such as ingested toxins or poor nutrition, which disrupt normal development. One result of these perturbations is asymmetrical development of body morphology (Gangestad and Thornhill, 1997b). Non-human studies indicate that FA is both heritable (Moller & Thornhill, 1997), and is affected by environmental events (Moller &: Swaddle, 1997; Kowner, 2001). Thus, observed individual differences in FA within a homogeneous population are expected to result in part from random individual differences in exposure to developmental insults, and in part from underlying heritable individual differences in the ability to develop normally despite exposure to such disruptive developmental events (Gangestad & Thornhill, 1999; Moller & Thornhill, 1997).

Most research concerning DI has operationalized FA as the manifestation of latent DI; thus the hypothesized relationships between DI and the other types of asymmetry, DA and antisymmetry, have been less thoroughly explored (Moller and Swaddle, 1997). Historically, FA was the only type of asymmetry believed to result from DI; DA and antisymmetry were believed to exist for adaptive functional purposes (Moller and Swaddle, 1997). However, this view has been challenged in some respects. Moller and Swaddle (1997) argued that although DA and antisymmetry do not themselves result from DI, individual differences in the magnitude of DA and antisymmetry reflect underlying individual differences in DI.

The present investigation focuses on testing hypotheses concerning causes of correlations between FA and psychological traits and behaviors. Questions concerning the evolutionary and biological basis of the relationship between DI and FA, while relevant to larger theoretical questions regarding FA, are not central to this investigation. While these are important theoretical questions in the biological sciences, they do not bear directly on the present investigation, which rather aims to employ a specific research design to test hypotheses that have been or might plausibly be advanced to explain the previously established correlations between human FA and behavior.

Measurement of Fluctuating Asymmetry

Most recent studies involving human FA have employed composite indexes of FA, usually composed of the summed average asymmetry of generally between four (e.g., Manning, 1995) and ten (e.g., Furlow et al., 1998) individual traits. The selection of traits is subject to a few requirements and restrictions. Foremost, individual traits or characters should be evaluated to determine if they meet the criterion of approximation of a normal distribution around a mean of zero (Moller and Swaddle, 1997). Failure on this test indicates DA and should result in the particular trait being eliminated from the composite index of FA. One limitation to the measurement of FA is that not all individual traits are amenable to precise measurement. This can be problematic because absolute differences between corresponding left and right traits often amount to less than a millimeter, and some commonly measured FA traits, such as ankle width, exhibit repeated-measures standard deviations far in excess of one millimeter (Arnold, Speir and Bronstad, unpublished data). The net result of these limitations is a severe constraint on the number traits that can be profitably used for human FA research. The most commonly used traits tend to be relatively small appendages, or parts of appendages, and are usually hard-tissue rather than soft-tissue characters. Examples of commonly measured characters include finger length, wrist width, elbow width, knee width, ankle width, foot width, hand width, ear height, and ear width (e.g., Furlow et al., 1998; Manning, 1995; Thornhill and Gangestad, 1994). The most common composite measures of human FA use some subset of the preceding or similar individual traits. For each trait, the absolute difference between the left and right trait lengths is divided by the mean trait length to yield the trait FA. The trait FAs are summed to yield a composite FA index (Palmer and Strobeck, 1986).

Another approach to measuring FA that is in relatively common use is the use of facial FA (e.g., Shackelford and Larsen, 1997). This technique uses facial photographs, on which the distances to each side of multiple bilateral traits are measured, usually horizontally from the vertical mid-line of the face, but sometimes along vertical dimensions . Body FA and facial FA have been found to correlate about +.60 (Gangestad and Thornhill, 1997b).

Fluctuating asymmetry has also been assessed using dental (e.g., Hershkovitz, Livshits. Moskona, Arensburg and Kobliansky, 1993), and dermatoglyphic (e.g., Mellor, 1982) traits although these methods are not in common use, and their correlations with body and facial FA have not been reported.

FA and Sexual Selection

Both the human and the non-human FA literatures indicate that FA is of far greater consequence to males than to females. This is generally assumed to be due to sexual selection (Gangestad and Thornhill, 1997b). When the sexes of a species differ in their reproductive investments, the greater investing sex (usually but not always females) will tend to exercise greater choice in the selection of mates (Trivers, 1972). This selection will evolutionarily drive traits of the lesser investing sex. This has been a common explanation for the importance of FA in males in many species, including our own (Gangestad and Thornhill 1997b). This does not imply that FA is of no consequence in females. In fact, FA is of consequence in females within both human and non-human animals. However, effects for males tend to be more pervasive, robust and generalizable (Moller, Soler and Thornhill, 1995; Thornhill and Sauer, 1992).

One contentious issue surrounding sexual selection theory concerns the question of which one of three widely described models accounts for sexual selection. This question is a general one in evolutionary biology, and applies to FA just as it does to many other putatively sexually-selected traits. One model, the arbitrary runaway selection model, posits that females initially prefer males for arbitrary reasons. However, if female preferences and male traits are heritable, they can become linked and will increase in subsequent generations relative to others who do not possess the preference or the preferred trait (Fisher, 1930; Gangestad and Thornhill, 1997b).

The second model is the good-genes model. According to this model females select as mates those males who possess superior genetically conditioned traits, such as disease resistance, fighting ability, speed or size. One of the major theoretical criticisms of this model is that this sort of selection regime cannot be maintained for many generations, since directional selection will tend to reduce genetic variability until all members of the population possess equal levels of the preferred trait (Gangestad and Thornhill, 1997b).

The third model, the good-provider model, does not make any genetic assumptions about the preferred traits. In this model preferences depend on phenotypic traits, which advertise a male's capacity for providing resources. In this model the preference is maintained as a result of the extra benefit it provides to the female and her offspring, regardless of the ultimate fitness consequences to the male. (Gangestad and Thornhill, 1997b).

It is possible that all the models are correct for different traits and conditions of selection (Gangestad and Thornhill, 1997b). Although there appears to be no consensus among evolutionary biologists with respect to which of these models is most often correct, most explanations for the apparent importance of DI in the animal kingdom implicitly or explicitly argue for the good-genes model of sexual selection (e.g., Jones, Little, Penton-Voak, Tiddeman, Burt and Perrett, 2001; Gangestad and Thornhill, 2003; Thornhill and Gangestad 1999; Gangestad, Simpson, Cousins, Garver-Apgar and Christensen, 2004). This is probably reasonable as FA is heritable (certainly in many non-human animals, and probably in humans) and it predicts many favorable reproductive and non-reproductive outcomes (Gangestad and Thornhill. 1997b).

Symmetry, Averageness and Facial Attractiveness

Several studies have found that FA predicts (negatively) ratings of facial attractiveness. Grammer and Thornhill (1994) found that facial FA predicted ratings of facial attractiveness by opposite-sex raters. They also found that facial FA predicted opposite-sex ratings of health and dominance for both men and women. Shackelford and Larsen (1997) found that facial FA predicted self-reported measures of psychological, affective and physiological health. Moreover, they found that facial FA predicted raters' judgments of health, replicating the research of Grammer and Thornhill (1994). However, they found no relationship between facial FA and ratings of attractiveness, though they speculated that this may have been due to using same-sex and opposite-sex raters (Shackelford and Larsen, 1997). Other evidence suggests sex of raters should not affect ratings of facial attractiveness. A meta-analysis by Langlois, Kalakanis, Rubenstein, Larson, Hallam and Smoot (2000) found that males and females tend to agree on ratings of facial attractiveness for both same-sex and opposite-sex ratings. These authors also found agreement across cultures.

Other studies have failed to find a relationship between facial symmetry and ratings of attractiveness (e.g., Langlois, Roggman and Musselman, 1994). This study and an earlier one (Langlois and Roggman, 1990) found that facial averageness relative to the population predicted ratings of attractiveness. This could be because individuals exhibiting population-average characteristics are less likely to carry rare deleterious genes, and thus would be desirable mates (Langlois and Roggman, 1990). It should be noted that this explanation and the good-genes argument based on studies of FA are not mutually exclusive; both could play a role in perceptions of attractiveness.

The results of a recent study in fact indicate that the issue of facial attractiveness is somewhat is more complex than merely a direct FA-attractiveness relationship. Gangestad and Thornhill (2003) found that facial FA and non-facial FA predicted masculinization of males' faces (i.e., wider jaw, longer chin, larger brow ridge) and that female raters preferred masculine faces, but only at the raters' periods of peak fertility, which was deemed by the researchers as consistent with the good-genes model of sexual selection.. During non-fertile periods preferences shifted toward relatively more "feminine" faces. Perhaps the conflicting findings in the literature will be explained to control for variables such as ovulation. There may be other moderating influences as well.

The literature is also inconsistent with respect to the importance of facial FA, or specifically with respect to its relationship to non-facial FA. In one study, for example, body FA predicted facial attractiveness ratings, with facial and non-facial FA correlating about $r = .60$ (Gangestad, Thornhill and Yeo, 1994). However, the same researchers (Gangestad and Thornhill, 2003) found in a separate study that facial FA and non-facial FA were uncorrelated.

In sum, the literature in this area indicates that both symmetry and averageness meaningfully predict ratings of facial attractiveness and that their effects seem to be independent predictors of attractiveness, possibly resulting from different evolutionary pressures.

<u>Non-human Studies of FA and Behavior</u>

There exists an extensive literature concerning FA in non-human animals. Many of the non-human studies focus on invertebrates, which have advantages over vertebrate studies because of better experimental control and relatively shorter generation intervals. Furthermore, many findings in studies of invertebrates have been found to generalize across the phylogenetic spectrum. Thornhill has conducted many studies of both human and non-human FA, including studies of invertebrates (e.g., Thornhill 1992a; 1992b; Thornhill and Sauer, 1992, Thornhill and Gangestad, 1994). Most of Thornhill's non-human research has involved various species of scorpionflies. In one study (Thornhill and Sauer, 1992), it was observed that among male *Panorpa vulgaris* FA related to two important fitness-related traits: salivary secretions and fighting ability. In this species, males secrete a ball of nutrient-rich salivary "nuptial food", which is offered to females to entice them to mate. Though this is not the only mating strategy in the species, it is a relatively effective one. The researchers separated males into two groups, secreters and non-secreters. They found that these groups differed in FA, with secreters being relatively more symmetrical. Among the offspring of these two groups, male and female offspring of the secreting group were superior in fighting ability and the male offspring of the secreters experienced higher levels of mating success.

In another study of two scorpionfly species, *Panorpa nipponsis* and *P. ochraceopennis,* Thornhill (1992b) found FA in males and females to predict the outcomes of interspecific contests over access to food resources, and to predict the mating tactics of males, with the asymmetric males employing less successful tactics. Similar results were found for *Panorpa japonica,* the Japanese scorpionfly, in which species the outcomes of fights between males over access to nuptial "gifts" (dead arthopods) was significantly related to forewing FA (Thornhill, 1992b).

Other studies of arthopods have obtained similar results. Wing-length FA has been found to correlate with mating success in male midges, *Chircmomus plumosols,* (McLachlan and Cant, 1995). Liggett, Harvey and Manning (1993) found a relationship between male wing and tibia FA and reproductive success in the yellow dung fly, *Scatophaga stercoraria.* And, Radesater and Halldorsdottir (1993) found a similar relationship in earwigs, *Forficula auricularia.*

Studies of vertebrates are fewer, but the findings are in general accordance with invertebrate results. Moller (1990) reported a significant relationship between male tail length (which correlates with FA) and female mate choice in swallows, *Hirundo rustica;* and Malyon and Healy (1994) reported that FA in male deer (*Dama dama*) antlers predicted a male’s position in the dominance hierarchy and ultimately mating opportunities.

The literature does provide examples of negative findings as well. For example, Oakes and Barnard (1994) found no relationship between experimentally manipulated male tail-feather FA and female choice in paradise whydahs, *Vidua paradisea;* and Markow, Bustoz. and Pitnick (1996) found no relationship between male sternopleural bristle number-FA or sex comb tooth number-FA and reproductive fitness in two *DrosophiIia* species, *D. simulans and D. pseudoobscura.* Despite these few negative findings, the literature is replete with examples of sex-related correlates of FA. Negative results do raise other issues, however. One is that it is likely that not all traits are affected by developmental perturbations to the same degree, or even at all. Thus it is important that morphological characters that reliably demonstrate FA be identified, and that the metric properties of such characters be described. Also, it is important to know which types of outcomes FA predicts. In some cases it is possible that FA predicts important consequences in a population, but a researcher has selected a trait that has no relationship to FA.

Another pervasive problem in FA research is low measurement reliability of FA (Thornhill, personal communication). This problem has received increased attention recently by FA researchers who recognize the need to develop reliable measures of FA to decrease the likelihood that true relationships will remain undiscovered due to biometric inadequacies. (e.g., Moller and Swaddle, 1997; Gangestad and Thornhill, 1999).

Human Studies of' FA and Behavior

Much behaviorally oriented research concerning human FA bas been conducted in the past few years. Thornhill and Gangestad (1994) published what was probably the first major study of behavioral correlates of FA in humans. They found that males' FA significantly correlated with number of lifetime sex partners (r= -.32) and with age at first sexual intercourse (r= .42), with age statistically controlled. These results were interpreted as supportive of the good-genes model of sexual selection.

Other studies have investigated the relationship between FA and ratings of attractiveness. For example, Gangestad, Thornhill and Yeo (1994) found non-facial FA of men correlated with ratings of their facial attractiveness. This may be one manifestation of the correlates of FA that lead to female preference for symmetrical males, but there are other findings, which suggest there are multiple female preferences related to FA. Manning (1995) found that male body mass correlated negatively with FA (r = -.51, n = 31). This finding is of interest in that it is well established that women prefer tall mates (e.g., Buss, 1994). An important question is whether women prefer tall men because they're symmetrical, or symmetrical men because they're tall, or whether these preferences operate independently. An examination of the literature reveals nothing of significance addressing this question. Gangestad et al. (1994) also found that women rate the faces of symmetrical men as attractive, which suggests that a full body assessment of the male is not necessary for females to make discriminations.

Another study found that women prefer the scents of relatively more symmetrical men compared with those of relatively less symmetrical men; however, this preference is found only during women's ovulatory period. (Thornhill and Gangestad, 1999). This finding was interpreted in light of the work of Baker and Bellis (1995), who found that women tend toward sexual infidelity during the fertile phase of their menstrual cycles, a finding that was interpreted as consistent with good-genes theory of sexual selection. Other studies have obtained similar results with respect to women's preferences for relatively more masculine faces during the fertile phases of their menstrual cycles (Penton-Voak and Perrett, 2000; Penton-Voak, Perrett, Castles, Burt, Koyabashi, and Murray, 1999). Another study found that women's preferences for male behavioral displays changed across the menstrual cycle. Women rated videotaped males as more attractive as a short-term mate during their fertile phases when the males displayed relatively greater social presence and intrasexual competitiveness (Gangestad, Simpson, Cousins, Garver-Apgar and Christensen, 2004).

If women are in fact seeking "good genes" when they cheat, relatively symmetrical males should not only be preferred, but should actually be *selected* as extra-pair mates at higher rates than relatively less symmetrical males. There is evidence that this is in fact the case. Gangestad and Thornhill (l997b) reported that males' FA negatively predicted self-reported number of sexual partners who were involved in a committed relationship at the time of sexual intercourse. Another relevant finding on this matter is that women with low-FA partners reported significantly more copulatory orgasms than did women with high-FA partners (Thornhill, Gangestad and Comer, 1995). This finding, when considered in light of the work of Baker and Bellis (1995), who suggest that the female orgasm serves a sperm-retention function, suggests the possibility that when women cheat on their partners, it is done in order to be impregnated by a "high genetic quality" male.

Another important behavioral correlate of FA in humans – and a variable of interest in the present study - is psychometric intelligence (Furlow, Armijo-Prewitt, Gangestad, and Thornhill, 1997). These researchers found that a composite FA measure correlated -.21 with Cattell Culture-fair Intelligence Test (CFIT) scores in an initial study of 112 university students (46 males and 66 females). In a follow-up study they obtained a correlation of -.24 in a mixed-sex sample of 128 university students. Unlike some other correlates of FA, intelligence correlated with FA in both males and females. The researchers offered two non-mutually exclusive hypotheses for this finding. One suggestion was that early developmental stress produces both compromised neural development and compromised morphological development. The other was that metabolic inefficiency is both the result of poor developmental precision and the cause of poor intellectual functioning.

Subsequent research has replicated and extended the link between FA and cognitive function. Jung, Yeo and Gangestad (2000) measured DI using a composite of FA and minor physical anomalies. DI predicted caffeine induced decrements in verbal working memory performance, although DI did not correlate with verbal working memory performance prior to caffeine administration. Yeo, Hill, Campbell, Vigil, and Brooks (2000) used magnetic resonance spectroscopy to assess neurochemical functioning during working memory tasks in children. They found that DI predicted neurochemical concentrations related to working memory performance. Rahman, Wilson and Abrahams (2004) found a small but significant correlation between FA and Raven's Standard Progressive Matrices scores (-.13) in a mixed-sex and mixed-sexual orientation sample. Among heterosexual men, they also found a significant correlation of -.32 between FA and Judgment of Line Orientation scores. Among homosexual men they found significant correlations between FA and Letter Fluency (-.29), Category Fluency (-.37), Synonym Fluency (-.27), and Digit-Symbol Substitution (-.36). There were no significant associations among female subjects.

Furlow et al. (1997) are representative in positing an environmental explanation for their findings. DI as measured by FA reflects underlying capacity to cope with stress. Those less able to develop normally despite these stresses have developed less efficient neural resources, which are particularly compromised under introduced conditions of stress.

However, there is a plausible alternative explanation – cross-assortative mating.

Within-family design

A within-family sibling study methodology described by Jensen (1980; 1998; Jensen and Sinha, 1993) provides a design useful for distinguishing between potential causal explanations for observed correlations between biological, psychological or behavioral traits. The within-family design uses the patterns of correlations among siblings and among unrelated individuals to test hypotheses concerning the causes of observed correlations between physical and behavioral traits. Different phenomena can cause physical and behavioral traits to be correlated, for example, genetic pleiotropy, genetic assortment, or common environmental factors (Jensen and Sinha, 1993). The within-family design allows one to eliminate certain of these possibilities based upon the observed patterns of correlations between and within families (i.e., sibling pairs). Two correlations are required for such tests, the between-family (BF) correlation, and the within-family (WF) correlation. The BF correlation is equivalent to the correlation in the population. The WF correlation is a between-siblings correlation. It indicates the extent to which members of a family (in this case full siblings) who score high on trait X also tend to score high on trait Y. If a statistically significant BF correlation obtains in a sample, the presence or absence of a statistically significant WF correlation determines the conclusions that be made concerning the possible causes of the relationship between the traits. According to Jensen (1998), not surprisingly, there are no reported cases of a statistically significant WF being found in the absence of a statistically significant BF correlation.

<u>Between-family and Within-family Correlations</u>

Jensen (1998) outlined a taxonomy of causes of correlations between physical and behavioral traits. As previously indicated, the most important distinction is between BF and WF correlations. This distinction between BF and WF correlations enables researchers to test hypotheses concerning the relative roles of intrinsic and extrinsic factors affecting the observed relationships.

<u>Intrinsic Correlations</u>

Intrinsic correlations in general are those in which the correlated traits are functionally and inexorably related to one another, and which are identified by the presence of a WF correlation (Jensen and Sinha, 1993). An example of a functional intrinsic correlation is one in which two traits are related as a result of a simple allometric relationship, such as exists in the relationship between height and the ability to reach high objects. Functional intrinsic correlations can also be caused by environmental factors that affect both traits. Jensen (1998) presents as a hypothetical example of this type of relationship a correlation between height and absenteeism in school children. In his fable children are given nutritional supplements (environmental factor) which cause both increased height and reduced absenteeism (due to illness reduction).

Genetic pleiotropy is another potential cause of intrinsic correlations (Jensen and Sinha, 1993). Pleiotropy is the condition when a single gene or set of genes affects two (or more) traits (Sutton, 1988). This type of intrinsic correlation may involve non-functional relationships between traits, although the traits are in these cases inexorably related to one another through a common genetic influence (Jensen 1993). An example in which a WF correlation was interpreted as pleiotropic was a study by Cohn, Cohn, and Jensen (1988), who conducted a sibling analysis of the relationship between myopia and intelligence. The BF and WF correlations were both significant, and the authors argued for pleiotropy on the basis of data that indicated that the near-reading hypothesis (the competing hypothesis they tested) could not account for the high incidence of myopia among high-IQ individuals. Although a plausible case for pleiotropy was made in this case, other unspecified environmental explanations could not be conclusively ruled out.

Two other genetic phenomena, linkage and supergenes can produce results that look like those resulting from pleiotropy (Sutton, 1988). Linkage occurs when two genes are located closely together on a chromosome, which causes them to not segregate independently during meiosis (Sutton, 1988). After many generations linkages tend to be broken up; however, in a single-generation study, such as a sibling study, long-term linkage trends cannot be observed, and any correlations produced by genetic linkage will be indistinguishable from pleiotropy. Supergenes refer to sets of linked genes which, due to coadaptive selective advantage, resist being broken up during meiosis (Jensen and Sinha, 1993). Like linkage, this influence is indistinguishable from pleiotropy in a single generation sibling study. And, unlike linkage, it would also be indistinguishable from pleiotropy in longitudinal analyses, due to its resistance to being broken up during meiosis (Jensen and Sinha, 1993)

Extrinsic correlations

Extrinsic correlations are those in which the traits are neither functionally nor causally related. They are identified by the absence of a WF correlation and the presence of a BF correlation. Simple genetic correlations are categorized as extrinsic correlations; these can be due to either genetic heterogeneity or cross-assortative mating. Genetic heterogeneity, or genetic stratification, occurs when the population is stratified into multiple sub-populations. In these instances if multiple genetically influenced traits differ by social stratum, these traits will be correlated in the population, assuming that people mate to some degree by social status.

Cross-assortative mating, unlike assortative mating which involves assortment along a single trait, such at intelligence, involves trait assortment in which mates engage in trade-offs between desirable traits. This phenomenon has been used to explain the observed BF correlation between height and IQ, for example (Jensen and Sinha, 1993). Height and intelligence are desirable traits in prospective mates (Buss, 1994), which situation produces a greater than random number of pairings between tall individuals and high-IQ individuals (in addition, of course, to the normal assortative mating that would exist for each height and IQ). The result of this mating pattern is the production of a correlation in the population between the two traits. Genetic heterogeneity is essentially a form of cross-assortative mating, but one in which the traits become associated by within-stratum mating, rather than by conscious selection of traits. These two types of simple genetic correlation are indistinguishable in sibling studies; both produce significant BF correlations in the absence of significant WF correlations.

Both of these types of simple genetic correlation result merely from the non-random segregation of genes. This means that the correlations are not functional, as defined by Jensen, and therefore are potentially reversible and transitory. Elimination of the selective forces that induced positive assortment on two traits can decouple the traits in a population, or, if reversed can even reverse the direction of the correlation.

In evaluating WF and BF correlations, there is an interpretive caution that should be considered. When trait-relevant environments differ between families, but not within families it is possible to obtain a result that looks like a simple genetic extrinsic correlation, but which is actually an intrinsic correlation due to common environmental influences on the traits. For example, if there are social class differences with respect to some relevant environmental factor, but these differences do not exist within families, the result will be a significant BF correlation and a non-significant WF correlation. When a sibling design produces this pattern of correlations, this intrinsic environmental type of explanation is indistinguishable from an extrinsic simple genetic explanation.

Although not included in Jensen's design, the addition MZ twin pairs to the within-family design would provide an analytical tool to narrow the number of possible causes of correlations when the results indicate that the within-family correlation is significant. If pleiotropy (or linkage or supergenes) is the cause of the correlation, there should be no significant correlation between the traits among MZ twins, since MZ twins are genetically identical. If the cause of the correlation is genetic, a higher scoring MZ twin on trait X should be no more likely than his co-twin to score higher on trait Y. On the other hand if the cause is environmental or allometric there will be a correlation within MZ twin pairs, since the twins can be differentially affected by environmental influences, which can jointly affect the two traits of interest, i.e. unshared environmental influences, or can affect the physical trait that is allometrically related to the behavioral trait.

A large number of MZ twin studies have found MZ twin birth weight differences to predict later IQ differences. In these studies, the heavier twin at birth tends to have a higher IQ in childhood (e.g., James, 1982, Scarr, 1969). This type of result is not limited to IQ; Riese (1994) found temperamental differences in discordant birth weight neonate MZ twins. With respect to FA and intelligence birth weight difference data would be informative if both the WF and MZ correlations are found to be significant. Such a result would indicate either an unshared environmental or an allometric explanation for the relationship. A significant correlation between birth weight differences and FA differences would indicate the existence prenatal environmental influences on the development of FA.

Dependent variables

As this review has catalogued there is a relatively small but growing number of behavioral and psychological traits that have been found to relate to FA in humans, particularly in males. In the present study, only four of these established traits were selected to ensure adequate statistical power for the relatively small sample that was targeted (Cohen and Cohen, 1975), three directly from the published literature, and one that was selected on the basis of an inference from previous studies.

A large proportion, if not the majority, of human FA studies have investigated sexual behavior. The DV of interest, sociosexuality, as defined by Simpson and Gangestad (1991) for example, concerns the extent to which an individual's sexual attitudes and behaviors are relatively "unrestricted", which denotes relative promiscuity, or "restricted", which is relatively more restrained. This trait will be measured using Simpson and Gangestad's (1991) Sociosexual Orientation Inventory (SOI).

The second DV is psychometric intelligence, which will be assessed by the Scholastic Level Exam (SLE) (Wonderlic, 1998), a highly g-loaded test of general intelligence, much like the CFIT used by Furlow et al. (1997). This variable is of special interest, since Furlow et al. propounded explicit causal hypotheses involving an intrinsic genetic and environmental causal explanation for the observed correlation.

The third DV is social dominance, which will be measured by a subset of California Psychological Inventory (CPI) (Gough, 1987) items from sub-scales related to social dominance (Craig, 1999).

The fourth DV is a measure of sociopolitical attitudes labeled libertarianism-totalitarianism (Mehrabian, 1996). The selection of this variable is on the basis of behaviors noted by Simpson et al. (1999), who found that low-FA males more frequently engaged in direct competition with other males in a study in which participants believed they were competing for the opportunity to date an attractive female study confederate. High-FA subjects on the other hand tended to avoid direct competition with other subjects. The inclusion of this instrument is intended to assess whether FA relates to competition beyond the sexual domain, specifically by measuring political beliefs along the dimension of libertarianism (free competition) to totalitarianism (government support).

Research hypotheses

Although research specifically addressing cross-assortative mating is minimal, there is substantial indirect evidence that cross-assortative mating does occur for many traits. Direct evidence indicates that, in the U.S. at least, cross-assortative mating occurs for physical stature and IQ (Jensen, 1998) and for physical attractiveness (in females) and occupational status (in males) (Udry and Eckland, 1984). It is surprising that, given the hundreds of published studies of assortative mating, there are very few addressing cross-assortative mating, particularly since the research literature would suggest that cross-assortative mating should occur among a number of traits. Studies of mate preferences (e.g. Buss, 1994) indicate that there exists a cross-culturally universal collection of traits that are desired in prospective mates. Some of these traits, such as intelligence, good health, and kindness, are relatively equally desired by both sexes, while others, such as physical attractiveness, and social status, are differentially preferred by males and females (Buss, 1994). The more important question relative to the present study of whether or not these preferences relate to actual mating patterns was not been as extensively investigated, although the evidence suggests they do (e.g., Buss and Barnes, 1986; Jensen, 1998; Udry and Eckland, 1984).

There is a very extensive literature on assortative mating (Elder, 1969; Jensen, 1978; Lykken and Tellegen, 1993; Taylor and Glenn, 1976; for a review see Thiessen and Gregg, 1980). It is well established that married couples positively assort on a large number of physical, psychological and behavioral traits. However, there is a debate as to why this occurs. Some argue that assortative mating exists for genetic matching, so that offspring will be related to their parents more closely than they would be under a regime of random mating (e.g., Thiessen and Gregg, 1980). Several other accounts have been proposed to account for this phenomenon, such as the idea that people select mates on the basis of propinquity, or that they mate based on their relative "values" on traits, with those individuals with high values on an attractive trait having first choice to mate with others who have high values on the trait, and so forth down the line (see Thiessen and Gregg, 1980 for a discussion of these various mechanisms). Unfortunately, most studies of assortative mating, even those reporting on a large number of traits, do not report the cross-correlations between traits.

Matings between attractive females and high-status males can be expected to produce many cross-correlations between physical and behavioral traits. Since social status correlates with height, IQ, and various personality/motivational traits (Gillis, 1984; Brody, 1992; Willerman, 1979), matings between attractive females and high-status males should result in positive spousal correlations between female attractiveness and male IQ, height, and personality traits related to social advancement. Because there probably are many traits involved in this process, most cross-assortative mating coefficients can be expected to be relatively small; however there should be a general trend of positive correlations. This result should obtain primarily because even highly desirable individuals will have difficulty finding mates who possess high trait-values of all, or even most, of the traits deemed desirable; thus, compromises or trade-offs are required. The composition of the collection of traits on which people will compromise will vary from individual to individual. And, perhaps most importantly, evaluators of a prospective mate's "mate value" will in turn themselves be evaluated and possibly eliminated from consideration. Certainly, few individuals will be characterized by high levels of most traits deemed of value to potential mates. The vast remainder will create less than perfect matches on the probably large number of traits of importance to this process. However, some processes, such as status matching and propinquity, that are believed to facilitate positive assortment on many single traits should also produce positive cross-assortment between traits (Thiessen and Gregg, 1980; Jensen, 1993).

On the basis of this evidence and rationale the first research hypothesis is:

<u>H1: The observed correlation between fluctuating asymmetry and intelligence</u>

results from cross-assortative mating.

This hypothesis is at variance with the majority of causal explanations for the relationship of FA to behavioral traits propounded by other researchers, which tend to the intrinsic and functional explanations. Cross-assortative mating, on the other hand, is an extrinsic nonfunctional explanation, in which one trait has no direct effect on the other, nor are the traits influenced by some common developmental or genetic factor. The within-family/twin methodology of the present study provides a test of this hypothesis against any of several competing functional intrinsic hypotheses.

The result of mating decisions based upon the preceding rationale should be small but pervasive positive cross-assortative mating coefficients for traits that are both heritable and desirable in mates. There is evidence that in human and non-human populations males exhibiting low FA are more desired as mates by females than are high FA males (for a review see Gangestad and Thornhill, 1997b). There is also evidence that FA is moderately heritable, (Moller and Thornhill, 1997), although none of the studies of human FA properly disentangled the influences of genes and environment, as they all used either parent-child or sibling comparisons. Thus it should be expected that the reported negative correlation between FA and IQ is at least partially attributable to cross-assortative mating for these traits. The within-family design will permit testing of this research hypothesis against the two hypotheses proposed by Furlow et al.

(1997), which are: 1) that the relationship exists as a result of early developmental perturbations which negatively affect symmetrical morphological development and neurological development, or 2) that the relationship exists due to the greater metabolic efficiency enjoyed by more symmetrical individuals. In terms of the modified sibling methodology, the cross-assortative mating hypothesis predicts a between-families correlation, whereas both hypotheses of Furlow et al. predict within-family and within-MZ twin pair correlations.

Social dominance is another correlate of FA for which a plausible case for cross-assortative mating can be made. To the extent that social dominance predicts social status and FA predicts attractiveness, cross-assortment between social status and attractiveness could account for the observed relationship between FA and social dominance.

H2: The observed correlation between fluctuating asymmetry and social dominance results from cross-assortative mating.

No rival hypotheses to this have been found in the literature. However, the unshared environmental hypothesis might reasonably be argued along the following lines: 1) low FA males tend to be larger and more physically robust that high FA males (Gangestad and Thornhill, 1997b) 2) other males will tend to defer to these individuals, which 3) leads to the development of high social dominance in low-FA males. This explanation would lead to a prediction of within-family and within twin pair correlations, whereas the cross-assortative mating hypothesis predicts a between-family correlation.

Sociosexuality is a trait for which the rival hypothesis seems relatively plausible. If sociosexuality in males does in fact derive in part from reaction to females' reactions to male FA, a within-family and within twin pairs correlation is predicted. Due to considerations of statistical power and alpha error, no specific hypothesis testing will be conducted for this relationship. However, exploratory analyses will be performed.

Libertarianism-totalitarianism is another trait for which the case for reactive unshared environmental influences is arguably more plausible than that for cross-assortative mating. It is quite easy to imagine high-status, attractive, intelligent, low-FA males developing *laissez-faire* attitudes regarding governmental or societal interference with free competition. Again, no specific hypothesis testing will be conducted for this relationship, though exploratory analyses will be performed.

METHOD

Participants and procedure

A total of 98 adult male participants took part in the study. This sample was comprised of 18 MZ twins, 6 DZ twins, 60 members of brother pairs, one set each of 3 brothers and 4 brothers, and 7 unpaired individuals. The mean age of the full sample was 31.7 (12.1). Ethnicity was 87 white, 4 Hispanic, 4 Asian, 1 black and 2 with unreported ethnicity. With respect to marital status, 49 were single, 39 married, 4 divorced and 6 did not report marital status. The primary within-family analyses involved only brother dyads, so the MZ twins and unpaired individuals were removed, leaving 73 participants for the primary analyses. Mean age of this sample was 29.8 (10.1). Ethnicity was 63 white, 4 Hispanic, 4 Asian and 2 with unreported ethnicity. Marital status was 41 single, 26 married, 2 divorced and 2 who did not report marital status.

Participants were recruited through a variety of means. Brother and twin pairs were recruited at the University of Texas via mass email and bulletin board postings. Twins were recruited by mail through the Twins Days mailing list, on site at the Twins Days celebration in Twinsburg, Ohio, and in person at a Michigan Twins Association annual celebration in Lansing, Michigan. Approximately one-third of participants were recruited by associates of the researcher in the regions surrounding Austin, Tex; Oxford Miss.; Pensacola, Fla., Washington, DC; and Indianapolis, Ind.. Participants were paid $10 each during the first phase of data collection at the University of Texas, and $20 each during subsequent phases.

Data were collected on the first thirty participants in a laboratory at the University of Texas. Data for12 MZ twin participants were collected on site at the Michigan Twins Association meeting. All other data were collected by mail. The procedure initially employed 5 FA traits: ear length, wrist breadth and 2nd, 3rd and 4th finger lengths. Finger FA was assessed from photocopies (as discussed in the Measures section) in both the on-site and mail out phases. Since ear length and wrist breadth were not amenable to the mailing procedure, they were eliminated from the composite FA measure, based on an obtained correlation of .75 between the 3-trait and 5-trait composite measures among the first 16 sibling pairs measured in the laboratory. The Scholastic Level Exam is a 12-minute timed test, but has provision for untimed administration. On site administration was timed, and instructions were provided to participants in the mailings for untimed SLE completion. Score corrections were applied to untimed administrations in accordance with published procedures (Wonderlic, 1998).

In the on-site sessions, participants first completed informed consent forms and demographic questionnaires. They then were measured for FA using 4 repeated measures for each side (left-right) of all FA traits. Finger lengths were taken from four independently obtained high resolution photocopies of participants' hands. Participants then were administered the SLE and the remaining questionnaires: Sociosexual Orientation Inventory, CPI-derived Social Dominance questionnaire, Mehrabian Libertarianism-Totalitarianism scale and a Social Group/Dating questionnaire. For subjects solicited by mail instructions were provided for completion of informed consent forms, questionnaires and tests. Detailed instructions were provided for obtaining four sets of photocopies of participants hands for finger FA measurement.

Approximately one-third of the way through the study, due to difficulty recruiting subjects the number of dependent variables was reduced from four to two. Subsequently the SOI and Mehrabian scales were not included in the mailings.

Both on-site and remote participants were assured of anonymity. Participants survey data packets were marked only with an alpha-numeric code to enable matching of sibling pairs. No personally identifying data were included on the returned or collected data. Completed items were contained in sealed manila envelopes for later scoring, and upon their return were separated from the return envelopes that contained participant contact information, consent forms and payment information.

Design

The primary study employs the within-family sibling design, as described by Jensen (1980, 1998; Jensen and Sinha, 1993), The MZ twin refinement described in the introduction was not available due to recruitment of only nine MZ twin pairs. For each pair of variables in the primary analyses, two correlations were calculated: between-families (BF) and within families WF). The BF correlation is the correlation between two variables in the sample using sibling-pair sums on the two traits. This correlation is equivalent to a correlation between the traits drawn from a sample of unrelated individuals from the same population. The WF correlation is the correlation between sibling difference scores for the two traits; that is, this correlation shows whether the scores on the two traits covary within sibships.

Age, which was found by Furlow et al. (1997) to covary with FA, and is established in the literature as a covariate of intelligence, was partialed out of the primary analyses.

Power analysis was initially conducted to determine the minimum sample size required to detect significant correlations with power of at least .70 at alpha =.05 for four dependent variables of interest (Hunter and Schmidt, 1990). This resulted in a required minimum sample size of 65 brother pairs. Due to subject recruitment difficulties this goal was reduced to two DVs with a power of at least .50. This analysis resulted in a required sample size of 43 pairs. Power was estimated for the weakest expected correlation, based on prior published studies, which was -.23 between FA and intelligence, as reported by Furlow et al. (1997).

In this case it was expected that the correlation would be greater than -.23, and if so should be detectable in this study for three reasons: 1) reliability of the FA measurement should be higher as a result of several methodological improvements over other FA measures (for a description of these improvements, see the Measures section), and 2) range restriction in IQ should be less than it was in the Furlow et a1. (1997) study because their study was restricted to college students, whereas this study included students and non-students and 3) because the alpha reliability of their measure of intelligence was reported to be only .46, whereas the published reliability of SLE varies from .82 to .94, depending on the type of reliability estimate used. Therefore, the power estimate for the FA by intelligence correlation probably errs on the conservative side.

Measures

Fluctuating Asymmetry (FA)

For all FA measurements Mitutoyo 200 mm digital calipers were used. This instrument measures to a tolerance of .01 mm, +/- .02 mm. Direct measures of ear height and wrist width were taken from the first 30 on-site participants. Measurements of the 2nd, 3rd, and 4th digits were taken from four independent pairs of photocopies of all participants' hands. The benefits of using photocopies rather than taking direct measurements were multiple. First, this method significantly reduced testing time. And as became important, it allowed for remote data collection. Also, measurement error is significantly reduced by taking photographic rather than direct measures (Arnold, Speir & Bronstad, unpublished data), possibly as a result of the reduction of movement and the elimination of the depth dimension. The need for standardization and measurement reliability of anthropometric variables has long been recognized (Roberts, 1975; Roebuck, 1995). This problem applies to the use of FA measures, since these depend on reliable anthropometric procedures (Fields, Spiers, Hershkovitz and Livshits, 1995; Moller and Swaddle, 1997) This study attempted to improve on typical FA measurement techniques. The use of photocopies for digit measurement has previously been found to reduce measurement error by about half (Arnold et al., unpublished data). Possibly the reason for this finding is that measurement error in photocopy-based measurements is affected only by a single dimension, length, while with direct measures it is affected by two dimensions length and depth.

In addition to improving the precision of single measurements, this study followed the suggestion of Moller and Swaddle (1997) to use repeated measures of each trait. Others in fact have done this (e.g., Furlow et al., 1997), however most researchers who have done so usually have taken just two sets of measurements. In the present study four repeated measures were obtained. Furlow et al. (1997) estimated their reliability by applying the Spearman-Brown Prophesy Formula (Nunnally and Bernstein, 1994), which in this case is equivalent to Cronbach's alpha, to their test-retest coefficient between their first and second measures, and estimated that the improvement in reliability from one to two measurements was .55 to .71. Using these figures as estimates for the present study, reliability was predicted to be about .83 using four repeated measurements. This estimate assumed that the composite FA measure would be as reliable as Furlow's. Although it employed fewer individual traits (first 5 and ultimately 3 instead of 9 traits), the present measure eliminated the least reliable of the commonly used individual traits, while improving the reliability those retained (i.e., by using photocopies for the 2nd, 3rd, and 4th digits and increasing the number of repeated measures). An analysis of the composite FA measure used herein confirmed these assumptions. Individual trait repeatability coefficients (presented in table 1) ranged between .983 and .994, while individual alphas of .82, .91, and .91 respectively were obtained for 2nd, 3rd and 4th fingers. For the composite measure alpha reliability was .89. Inter-trait correlations were also computed in the full sample of 98: 2nd/3rd fingers $r = -.01$, n.s.; 2nd/4th fingers $r = .04$, n.s.; 3rd/4th fingers $r = .30$, $p < .05$.

Calculation of FA followed Palmer and Strobeck (1986). For each individual trait, $FA = |R-L| / [(R+L) \times .5]$. This formula has been used by many of the recent investigators of human FA (e.g. Thornhill and Gangestad, 1994). A check for directional asymmetry (DA) was performed. No statistically significant DA was found (see Table 2).

Table 1.
Paired-samples t-tests for directional asymmetry

Character	N	Mean	SD	SEM	t	df	sig.
2nd finger	79	-.067	1.25	.141	-.476	78	.636
3rd finger	79	.040	1.32	.149	.309	78	.758
4th finger	79	-.184	1.11	.125	-1.48	78	.144

NOTE: Character values are right minus left sides of characters in millimeters.

Table 2.
FA character repeatability correlation matrices

Right 2nd finger

	2	3	4
1	.992	.994	.992
2		.992	.989
3			.993

Left 2nd finger

	2	3	4
1	.989	.992	.988
2		.990	.992
3			.993

Right 3rd finger

	2	3	4
1	.990	.991	.990
2		.992	.990
3			.992

Left 3rd finger

	2	3	4
1	.989	.989	.990
2		.988	.990
3			.991

Right 4th finger

	2	3	4
1	.985	.987	.988
2		.987	.983
3			.987

Left 4th finger

	2	3	4
1	.983	.983	.987
2		.984	.987
3			.990

Tests and Questionnaires

Several published and unpublished paper-and-pencil psychometric instruments were administered.

Scholastic Level Exam

The Wonderlic SLE (Wonderlic Personnel Test, Inc., 1998) was used to measure psychometric intelligence. This instrument has been widely administered over the past half-century, and its excellent psychometric properties are well established (Buros, 1975). This test has been demonstrated to have a high loading on the general factor of mental ability (g) (Buros, 1975). Correlations between the SLE and other highly g-loaded intelligence range from the low .80s to the high .90s (Wonderlic, 1998). Test-retest reliability is reported to range between .82 and .94 and internal consistency reliability is reported as .88 to .94 (Wonderlic, 1998). The most attractive feature of the test is its brevity; administration takes a mere 12 minutes. It also provides for untimed testing, with appropriate score correction procedures (Wonderlic, 1998).

Sociosexual inventory (SOI)

Sociosexuality was measured by the Sociosexual Orientation Inventory (SOl) (Simpson and Gangestad, 1991). The SOI has been used in previous research related to FA and sexual activity (Simpson, 1997; Cousins, Gangestad, Simpson and Christensen, 1998), and has been found to correlate significantly with FA (Simpson, 1997). This instrument consists of seven items that measure attitudes and behaviors related to sexual promiscuity, including number of sexual partners, infidelity and casual sexual relations. (Simpson and Gangestad, 1991). Test-retest reliability over a two-month interval was reported as .94 (Simpson and Gangestad, 1991).

Social Dominance

Social dominance was measured by a 115 item questionnaire derived from the California Psychological Inventory (CPI) (Gough, 1987). This approach was taken to reduce total testing time. The full CPI is a 434 item instrument comprising 19 personality scales, including three validity scales (Craig, 1999). The social dominance composite scale was created by aggregating several abbreviated scales derived from the CPI consisting of items from three dominance-related scales: Dominance (Do), Capacity for Status (Cs), and Social Presence (Sp). The instrument also included subsets of items from three CPI validity scales: Well Being (Wb), Good Impression (Gi), and Communality (Cm), in addition to 10 items from the Sociability (Sy) scale, which were included to assess discriminant validity. Although Sy is correlated with Do, Cs and Sp, it is differentiated by behavioral outcome. Carson and Parker (1966) found that Do, but not Sy, predicted scores on a leadership index among college students. Factor II (i.e., Do, Cs, Sp) CPI scales have been found to correlate with other psychometric and behavioral measures of dominance, such as the Edwards Personal Preference Schedule Dominance Scale, Ascendancy, leadership achievement among National Merit Scholars and Executive Leadership in industry (Megargee, 1972). For the present study, raw scores were calculated for each of the seven scales. Additionally a composite social dominance score was calculated by summing Do, Cs and Sp scores, which, on the high end of the scale, describes individuals who enjoy being the center of attention and who may be charismatic, persuasive leaders (Craig, 1999). Thirty filler items were also included as distracters. Table 3 lists the CPI items included in these scales. Table 4 reports abbreviated scale intercorrelations. Due to the abbreviated scales, published psychometric norms for the CPI are not applicable.

Table 3.
California Psychological Inventory items used in abbreviated scales

Dominance (Do)	53, 202, 267, 310, 314, 319, 320, 355, 359, 369
Capacity for Status (Cs)	17, 32, 40, 49, 154, 186, 201, 220, 230, 237
Social Presence (Sp)	2, 4, 50, 58, 74, 77, 208, 251, 280, 285
Self-Acceptance (Sa)	21, 86, 104, 138, 146, 182, 185, 216, 284, 291
Communality (Cm)	321, 324, 332, 342, 349, 350, 360, 366, 374, 384
Good Impression (Gi)	34, 48, 56, 66, 78, 120, 178, 195, 203, 254
Well-Being (Wb)	89, 266, 276, 299, 306, 308, 344, 353, 398, 413
Sociability (Sy)	1, 111, 124, 163, 167, 242, 284 ***
Distracter items	9, 14, 24, 39, 42, 65, 69, 75, 87, 95, 129, 141, 199, 205, 209, 228, 246, 323, 331, 391, 397, 409, 435, 475, 480

NOTE: ***Three new items were written specifically for the Sy scale: "I enjoy spending time alone", "I like large crowds" and "I prefer a small gathering over a large party".

Table 4.
Abbreviated CPI scale correlation matrix

	Do	Cs	Sa	Sp	Sy
Do		.22*	.49**	.47**	.47**
Cs			.47**	.37**	.42**
Sa				.51**	.36**
Sp					.60**
Sy					

NOTE: n = 79, * p < .05 one-tailed, ** p<.01 one-tailed

Libertarianism-Totalitarianism

Socio-political orientation was measured by the Mehrabian Libertarian-Totalitarianism Scale (Mehrabian, 1996). This 20 item questionnaire measures attitudes concerning an individuals' and government's roles in society, ranging from endorsement of free and open competition on the libertarian end of the scale to government support and intervention on the totalitarian end of the scale (Mehrabian, 1996). Internal consistency reliability was reported as .86 (Mehrabian, 1996).

Social Group/Dating Questionnaire

A six item questionnaire was included that measured relative ratings of brothers on such traits as likelihood of getting in physical fights, leadership qualities, and dating success. This instrument is reproduced in appendix B. A demographic questionnaire was also administered, and is reproduced in appendix A.

RESULTS

Primary analyses were limited to WF and BF correlations for FA x IQ and FA x Social Dominance. Exploratory analyses were performed on the remaining variables and on the small sample of MZ twins. Of the complete sample of 98 participants, seven were eliminated from the primary analyses due non-collection of their brothers' data. Eighteen (nine dyads) were MZ twins, and thus were eliminated from the primary within-family analyses. This resulted in a sample of 73 participants for the primary analyses. These participants comprised 42 full-sibling brother dyads (33 pairs, one set of three, and one set of four brothers). Tests of skewness and kurtosis were performed on all variables in the primary and exploratory analyses, as well as control variables. Table 5 provides descriptive and univariate normality statistics for the full sample of 98 participants.

Table 5.
Full sample descriptive statistics and normality statistics.

Variable	n	M	sd	range	skew	kurtosis
FA	97	.039	.020	.011/ .098	.89*	.20
SLE	96	28.21	5.39	9 / 41	-.76*	1.81*
Soc. Do	93	18.73	3.28	10 / 25	-.35	-.04
CPI abbreviated scales						
Do	93	6.05	1.51	1 / 9	-.43	.54
Cs	93	5.96	1.22	3 / 8	-.10	-.52
Sa	93	6.26	1.34	3 / 8	-.62*	-.21
Sp	93	6.72	1.64	3 / 10	-.27	-.54
Cm	93	8.27	1.31	5 / 10	-.69	.22
Wb	93	6.95	1.22	3 / 10	.10	.46
Sy	93	5.03	1.92	2 / 9	.34	-1.04*
Lib.-Tot.	34	19.63	23.93	-32 / 73	-.11	-.37
SOI	29	63.48	45.49	15 / 223	1.88*	4.42*
Age	96	31.66	12.06	18 / 72	1.29*	1.689*
Ht. (in.)	98	71.19	2.26	65 / 78.25	.106	.798
Wt.(lb.)	98	178.3	25.43	135 / 300	1.40*	4.32*

NOTE: * indicates skewness or kurtosis exceeds critical ratio (CR) of 2 or –2 times standard error. FA = fluctuating asymmetry; SLE = Scholastic Level Exam; Soc.Dom. = social dominance; Lib.-Tot = Libertarianism-Totalitarianism; SSI = Sociosexual Orientation Inventory.

Table 6 provides descriptive and normality statistics for the sample of 73 participants used for the primary analyses: Fluctuating Asymmetry (mean = .040, SD = .020), SLE (mean = 29.63, SD = 4.14), and Social Dominance (mean = 18.74, SD = 3.25). FA was found to be positively skewed (skew = .962, CR = 3.40). Additionally table 6 provides descriptive statistics for variables of interest in the exploratory analyses: Libertarianism-Totalitarianism (mean = 21.38, SD = 24.48) and Sociosexuality (mean = 63.48, SD = 45.47). Sociosexuality was found to be positively skewed (skew = 1.88, CR = 4.33) and leptokurtotic (kurtosis = 4.42, CR = 5.23).

Table 6.
Primary and exploratory variable descriptive statistics and normality statistics.

Variable	n	M	sd	range	skew	kurtosis
FA	72	.040	.020	.012 / .098	.963*	.258
SLE	73	29.63	4.14	17 / 41	.009	.405
Soc. Dom.	70	18.74	3.25	11 / 25	-.26	-.14
Lib.-Tot.	30	21.38	24.48	-32 / 73	-.25	-.29
SOI	29	63.48	45.49	15 / 223	1.88*	4.42*
Age	73	29.82	10.05	18 / 53	.83*	-.26
Height (in.)	73	71.27	2.27	66 / 78.25	.32	.85
Weight (lb.)	73	177.91	25.79	135 / 300	1.63*	5.94*

NOTE: * indicates skewness or kurtosis exceeds critical ratio (CR) of 2 or –2 times standard error. FA = fluctuating asymmetry; SLE = Scholastic Level Exam; Soc.Dom. = social dominance; Lib.-Tot = Libertarianism-Totalitarianism; SSI = Sociosexual Orientation Inventory.

Primary analyses

Between-family and within-family partial correlations between FA and intelligence were computed, with age partialed out. The results supported the hypothesis that the correlation between FA and intelligence is at least partially attributable to cross-assortative mating for FA and intelligence. The obtained values were: between-family ($r = -.323$, $p < .025$) (one-tailed), $df = 38$); within-family ($r = -.174$, p = n.s. (one-tailed), $df = 38$). Between-family and within family partial correlations were also obtained for FA and Social Dominance, again with age partialed out. The results did not support the hypothesis that cross-assortative mating contributes to the observed correlation between FA and Social Dominance. Neither BF ($r = .080$, p = n.s. (one-tailed), $df = 36$) nor WF ($r = -.132$, p = n.s. (one-tailed), $df = 36$) correlations between FA and Social Dominance were significant. Neither did any of the component scales comprising the composite social dominance scale significantly relate to FA in either the full sample or in the brother dyad sample; zero order correlations ranged between -.06 and .10. Dyad means, difference scores, and other descriptive statistics for the primary analyses are reported in table 7. Although it is at variance with Jensen's approach, it is informative to test the significance of the difference between these correlations. For FA and intelligence, the difference between the correlations was not statistically significant: $z = .708$, $n = 42, 42$, p = n.s. (one-tailed).

Table 7.
Descriptive statistics for between-family and within-family analysis of fluctuating asymmetry, intelligence and social dominance.

Variable	N	M(SD)	Range	Skew	Kurtosis
Age Difference	42	.095(2.90)	-6 / 6	.01	-.78
Height Dif.	42	-.30(2.73)	-8.5 / 6	-.53	1.62*
Height Mean	42	71.36(1.85)	67 / 75.75	-.10	.37
FA Dif.	41	.000(.021)	-.049 / .048	-.06	.78
FA Mean	41	.038(.017)	.019 / .083	1.02*	.14
SLE Dif.	42	-.90(5.16)	-11 / 13	.51	.06
Soc. Dom. Dif.	40	-.38(3.76)	-7 / 7	.09	-.76
Soc. Dom. Mean	40	18.86(2.62)	13 / 22.5	-.60	-.18

NOTE: * indicates skewness or kurtosis exceeds critical ratio (CR) of 2 or –2 times standard error. FA = fluctuating asymmetry; SLE = Scholastic Level Exam; Soc.Dom. = social dominance; dif. = difference score. Difference scores were computed by subtracting trait value of the second sibling from the trait value of the first sibling. The ordering of siblings was random.

Exploratory analyses

Considerations of statistical power and alpha-error limited the present investigation to two hypothesis tests. However, data were collected on an array of other variables. The following results must be considered exploratory and preliminary, and are presented for the purpose of informing future research initiatives.

Between-brother zero-order Pearson product-moment correlations were obtained for many variables of interest, as shown in table 8. Table 9 shows the complete sibling sample zero order correlations. As expected, and largely consistent with decades of scientific literature, brothers in the present study were found to covary on a wide array of traits: height ($r = .296$, $p<.05$ one-tailed, $n = 42$); weight ($r = .624$, $p < .01$ one tailed, $n = 42$); FA ($r = .419$, $p < .01$, $n = 41$); intelligence ($r = .150$, n.s., $n = 42$); libertarianism-totalitarianism ($r = .517$, $p < .05$, $n = 15$); sociosexuality ($r = .413$, n.s., $n = 14$); social dominance ($r = .325$, $p < .05$, $n = 40$). Correlations between FA and established or claimed correlates of FA were obtained from the full sample of 72 brothers: FA x height ($r = .083$, n.s., $n = 72$); FA x weight ($r = .076$, n.s., $n = 72$); FA x age ($r = -.194$, n.s., $n = 72$). Additionally, correlations of FA with two other traits eliminated from primary analysis by power and alpha-error considerations were also obtained: FA x sociosexuality ($r = -.124$, n.s., $n = 29$); FA x Libertarianism-Totalitarianism ($r = .195$, n.s., $n = 30$). Neither of these last correlations was statistically significant, and only the former was in the hypothesized direction.

Table 8.
Between-brother zero order correlations for study variables

	HT	WT	FA	SLE	L-T	SOI	S-D
HT	**.296***	.319*	.050	.073	.006	.148	.066
n	**42**	84	83	84	30	29	81
WT		**.624****	-.003	.089	.104	.155	.053
n		**42**	83	84	30	29	81
FA			**.419****	-.179	.303	.057	-.007
n			**41**	83	30	29	80
SLE				**.150**	.136	.152	-.028
n				**42**	30	29	81
L-T					**.517***	-.171	.142
n					**15**	29	30
SOI						**.413**	.307
n						**14**	29
S-D							**.325***
n							**40**

NOTE: . HT = Height; WT = Weight; FA = Fluctuating Asymmetry; SLE = Scholastic Level Exam; L-T = Libertarianism-Totalitarianism; SSI = Sociosexual Orientation Inventory; S-D = Social Dominance. Zero order Pearson product-moment correlations. *statistically significant at p < ..05; ** < .01, one-tailed.

Table 9.
Variable intercorrelations matrix: full dyad sample

	HT	WT	FA	SLE	L-T	SOI	S-D	Age
HT	**-**	**.536****	**.083**	**.161**	**.165**	**.096**	**.098**	**.108**
n	73	73	72	73	30	29	70	73
WT		-	**.076**	**.237***	**.087**	**-.011**	**.090**	**.338****
n		73	72	73	30	29	70	73
FA			-	**-.336****	**.195**	**-.124**	**.018**	**-.194**
n			72	72	30	29	69	72
SLE				-	**-.134**	**-.022**	**-.040**	**.244***
n				73	30	29	70	73
L-T					-	**-.237**	**.323***	**-.179**
n					30	29	30	30
SOI						-	**.534****	**-.087**
n						29	29	29
S-D							-	**.206***
n							70	70
Age								-
n								73

NOTE: HT = Height; WT = Weight; FA = Fluctuating Asymmetry; SLE = Scholastic Level Exam; L-T = Libertarianism-Totalitarianism; SSI = Sociosexual Orientation Inventory; S-D = Social Dominance. Zero order Pearson product-moment correlations. *statistically significant at $p < ..05$; ** < .01, one-tailed.

The Social Group/Dating Questionnaire contained six items requiring the participants to compare themselves with their brothers. On each of the items a participant responded whether he or his brother was better described by a particular behavior or trait, or whether they were the same. Agreement was defined as both brothers identifying the same individual. A questionnaire design flaw confounded responses of “same” with answers left blank, thus several were excluded from the analysis on this basis. As shown in table 10, kappa was obtained as a measure of agreement for each of the six items, five of which showed significant agreement between brothers: item 1, “In social situations, who is more of a natural leader?” (valid cases $n = 31$, kappa = .547, $p = .002$); item 2, “Who has an easier time making new friends?” (valid cases $n = 32$, kappa = .377, $p = .031$); item 3, “Which of you can more easily get a date?” (see appendix B for full item) (valid cases $n = 28$, kappa = .565, $p = .003$); item 4, “Who is a better athlete?” (valid cases $n = 33$, kappa = .276, $p = .022$); item 5, “Who is more physically attractive?” (valid cases $N = 21$, kappa = .447, $p = .027$); item 6, “Who is more likely to get into a fistfight?” (valid cases $n = 30$, kappa = .156, $p = .367$).

Table 10.
Sibling agreement on Social Group/Dating Questionnaire

Item number	N	N agree	κ	SE	Approx. T	Approx. p
1	31	24	.547	.15	3.05	.002
2	32	22	.377	.16	2.15	.031
3	28	22	.565	.16	3.02	.003
4	33	19	.276	.10	2.30	.022
5	21	15	.447	.18	2.21	.027
6	30	17	.156	.17	.90	.367

NOTE: N = number of valid responses; N agree = number of dyads in which members agree on identity of higher and lower member of pair for item; SE = asymptotic standard error, not assuming the null hypothesis; Approx. T = approximate T, using the asymptotic standard error assuming the null hypothesis

These exploratory analyses were performed to assess whether characteristics found in the literature such as mating success, aggressiveness and athleticism, putatively related to FA, did in fact differ between brothers, a similar design, though not correlational, to the BF/WF design. For the five items exhibiting agreement between brothers, criterion groups were set up consisting of higher-rated brothers in one group and lower-rated brothers in the other group. One-way ANOVAs were performed with FA as the dependent variable. No statistically significant differences in FA were found, which tends to support the notion that correlates of FA are population level (of between-family) phenomena not found within families. This interpretation would tend to support the argument for cross-assortative mating for low-FA and other positive attributes accounting for the observed population level associations.

Due to the extremely small number of MZ twins recruited (9 pairs) they were not included in any of the primary analyses. However, correlational FA, SLE and height data are presented for the sake of interest. One pair of MZ twins did not complete the SLE, so there are only eight observations for correlations involving that variable. For FA x SLE $r = -.12$, n.s., $n = 8$, for FA x height $r = -.33$, n.s., $n = 9$, and for SLE x height $r = .77$, $p < .05$, $n = 8$.

DISCUSSION

FA measurement

The use of four independent measurements of each FA component coupled with measurement stabilization resulting from the use of photocopies rather than direct trait measurement produced a highly reliable measure of FA. The value of increasing the number of repeated measurements of each trait is well established (Nunnally and Bernstein, 1994). However, the additional value of the stability afforded by photocopies cannot be overstated. Inter-measure repeatability coefficients were all above .98. The result was an internal consistency reliability of .89 for the composite FA measure, higher than any reported human FA reliability that could be found in the literature.

Since developmental instability is imperfectly manifested as FA it is probably fair to state that the added loss of reliability resulting from poorly measured FA has in the past led researchers to conclude no relationship exists in cases where a more reliable FA measure would have uncovered one. Similar measurement approaches to that used in the present study are highly recommended to future FA researchers. It is noted also that the obtained correlation between FA and intelligence of -.32 in the present study exceeds those obtained by Furlow et al. (1997), which were -.21 and -.24, primarily as a result of improvements in the reliability of the FA and the intelligence measures, which were described previously. In fact, the correlation obtained herein may be seen as a fairly close replication of the work of Furlow et al. (1997). When their measures of FA and intelligence - each of which was substantially less reliable than its counterpart in the present study - are disattenuated, the estimated true correlations between FA and intelligence in their two studies are -.37 and -.42 (McDonald, 1999). In the present study the disattenuated correlation between FA and intelligence is -.38 (McDonald, 1999). In much FA research it is likely that poor reliability characterizes not just the FA measure, but the other measures of interest as well, given that these are frequently observational ratings or self-report measures.

Primary analyses

The observed BF correlation between FA and psychometric intelligence in the absence of a statistically significant WF correlation supports the hypothesis that the relationship is, at least in part, a result of an extrinsic causal factor, most likely cross-assortative mating for FA and intelligence. A large literature on mate preferences and a somewhat smaller literature on mate choice suggest strongly that this should be so. However is seems somewhat remarkable that despite a large body of evidence that specific, universal mate preferences exist (Buss, 1994), relatively much less attention has been paid to the influence of these preferences with respect to mate choice and on the resulting impact on spousal and within-family trait intercorrelations (for one exception see Buss &

Barnes, 1986). The existence of cross-assortative mating for FA and intelligence should not be a surprise. Rather it would be surprising if two heritable traits universally rated as desirable characteristics in prospective mates were not found to be spousally correlated. However, with the notable exception of a substantial number of findings of cross-assortment for height and intelligence going back over a period of many decades (Jensen and Sinha, 1993), and of a smattering of studies finding cross-assortment for male status and female attractveness (e.g., Udry and Eckland, 1984) there has been surprisingly little research specifically addressing cross-assortative mating.

The implications for cross-assortative mating on any socially relevant traits are quite significant. Many studies have investigated the social correlates of psychological, behavioral or physical variables. When investigating traits subject to cross-assortative mating researchers should ensure they account for the cross-assorted variables. For example, the popular finding that taller individuals have higher incomes than the generality may likely be the result of cross-assortment for height and other desired mate characteristics, such as intelligence.

With respect to the growing body of research concerning FA and cognitive ability, including intelligence, the present findings argue against the predominant non-shared environmental causal explanation. Research utilizing the within-family design or some other method for distinguishing between causal influences should be employed in future investigations. The relatively small sample used in the present research was not sufficient to test whether a smaller environmental variance component also influences the observed correlation between FA and intelligence or whether the phenomenon is likely due solely to cross-assortative mating. The within-family correlation of -.17 in the present study was not statistically significant, but until this research is replicated on a much larger sample, the possibility of a smaller non-shared environmental influence should not be disregarded.

The second research hypothesis that FA is correlated with social dominance in the general population as a result of cross-assortative mating was not supported by the present research. In fact the failure to replicate this finding from previous studies raises questions about the procedures employed in the present study, including construct validity of the CPI derived scale employed. The replication of earlier studies showing a relationship between FA and intelligence argues against the possibility that the failure to replicate for social dominance was due to lack of validity in the FA composite measure. It is unclear whether this finding represents merely a chance failure to replicate or was the result of selecting an inappropriate instrument with which to measure social dominance. Based on previous studies of CPI scales, the choice of Do, Cs and Sp seemed to be appropriate choices. These scales are highly intercorrelated, loading on the same social dominance factor, or "class I scales" (Megargee, 1972). These scales correlate highly with not only external measures of dominance or social dominance, but also with behavioral ratings of leadership across many studies (Megargee, 1972). Although several FA studies have employed observer ratings of dominance meaning the dominance behavior could have been context specific, at least one study (Gangestad and Thornhill, 1997b) used a social dominance scale derived from the California Q-sort and found it to correlate significantly with FA. Unfortunately these researchers did not describe specifically how their instrument was constructed, so a more thorough investigation into possible differences is not possible.

The issue of context specificity may be important. It has been seen that females' mate preferences are to some extent dependent upon ovulatory state. It could be possible that the dominance behavior observed in previous studies was conditional upon the circumstances of the study, some of which employed inter-sex interactions specifically designed to elicit intra-male competition. Just as is found with female preferences, it is possible that some male behaviors rated as socially dominant are in fact situationally specific to the mating domain. Only the Thornhill and Gangestad (1997b) study would seem to argue for a trait-level association between social dominance and FA. The predominant behavioral correlate of the social dominance scales of the CPI in previous studies has been ratings of leadership, among peer groups, social organizations or within industry settings, for example (see Megargee, 1972 for a review of these studies).

The results of the FA and intelligence analysis raise important questions concerning the mechanism of cross-assortative mating. The issue is rather murky in fact, and the data from the present study do not provide satisfactory answers. Male FA has previously been found to correlate with females' preference for male scent (Thornhill and Gangestad, 1999), social dominance (Gangestad and Thornhill, 1997b), tendency toward violence (Furlow et al., 1998), physical size (Manning, 1995), facial masculinization (Gangestad and Thornhill, 2003), and ratings of physical attractiveness (Gangestad et al., 1994), doubtless among others. This diversity of correlates of FA raises the question: which if any one or more of these is directly targeted in mate choice decisions? And for that matter, is intelligence even directly targeted in these decisions? It is well documented that intelligence predicts occupational attainment and social status (Willerman, 1979). It could be the case that intelligence and FA are indirectly subject to cross-assortment due to mating choices based upon characteristics correlated with these traits. Gangestad et al. (2004) found that cycling ovulating women at the peak phase of fertility preferred men with three characteristics known to be associated with FA: positive scent, masculine facial features and social presence, with the largest effects for social presence. It seems perfectly reasonable to assume that one of these other characteristics, among many other conceivable possibilities, could be the subject of mate choice, while FA itself is merely an associated trait that has no direct relevance to mate choice. This could perhaps explain the report of Langlois et al. (1994) who found no relationship between facial symmetry and ratings of attractiveness. In this study the researchers manipulated photographs to create symmetrical faces. However, if it is not symmetry, but some other characteristic, such as masculinization of facial features, that is associated with FA that is the real influence on attractiveness ratings then these negative findings based on artificially created symmetrical faces would be expected. The matter of untangling these relationships will require considerably more future research.

Exploratory analyses

The relatively small sample sizes for the analyses concerning FA and sociosexuality and libertarianism-totalitarianism render discussion of these results almost meaningless. Neither trait was found to correlate significantly with FA in the overall sample and only sociosexuality correlated in the hypothesized direction, though at a miniscule r = -.12 among the 29 subjects who completed this scale.

The results of the sibling pair responses to the Social Group/Dating Questionnaire are rather interesting, though exploratory and tentative at this point. The six items on this questionnaire were developed based on general observations from the FA literature bearing on characteristics that seem to be associated with FA, as have been described in some detail previously: attractiveness, mating behavior, violence proneness, and dominance/leadership for example. On the five items for which there was statistically significant agreement as to which member of the sibship was better described by the item (e.g., "Who is more physically attractive?") there was no association at all between rank order on the item and FA scores. The data necessary to conduct a thorough analysis were unfortunately not collected, specifically the association between the characteristics rated and FA in the full sample. But, if based on their position in the established literature, particularly for such established characteristics as attractiveness, these ratings can be treated as meaningful, then this manipulation is functionally equivalent to a within family analysis, which in this case points to no within family association between FA and these various associated characteristics. It bears repeating that due to considerations of overall alpha and the risk of type I error these analyses are to be interpreted with caution. However, should they be replicated in the future on a larger sample the results of this particular analysis would seem to lend weight to the argument that cross-assortative mating is a factor in at least some of the observed associations of FA.

The MZ twins analysis should be interpreted cautiously as well, if at all, obviously due to consideration of overall alpha-error, but due to the very small sample of twins in this study. With respect to the very large body of data concerning the correlation between IQ and height, Jensen and Sinha (1993) summarized a number of studies and conclude that the BF correlation for height x IQ is about .20, while the WF correlation is slightly under .05, indicating that the relationship is largely due to cross-assortative mating for height and intelligence. However, they cite a study of MZ twins that found the correlation between twin-pair IQ difference scores and height difference scores was .47 in a sample of 20 MZ twin pairs. They explained that this seemingly large intrinsic (environmental) effect is to be expected even when the environmental influence on the correlation between height and IQ is quite small in the general population. This is due to the fact that environmental and developmental influences are magnified in MZ twin analyses since there is no genetic source of variance available for these highly heritable traits. All the non-error variance is environmental variance. In the present study the correlation among the eight MZ twin pairs from which height and SLE data were available the correlation between height and SLE difference scores was .77. For FA and SLE the correlation between difference scores among the eight MZ twin pairs was -.12. While the sample size upon which this result was obtained is too small to allow confidence in the accuracy of the result, it is noted that this pattern is what one would expect to find if the correlation were due to cross-assortative mating rather than to non-shared environmental factors. It would be of great interest to see this analysis performed using a much larger sample of MZ twin pairs.

Limitations

The most severely limiting factor with the most widespread consequences concerned significant difficulties recruiting the desired number of subjects for the study. As a result the number of targeted dependent variables in the primary analyses was halved and the use of MZ twins in the primary analyses was abandoned. The latter was of small consequence since the primary advantage of MZ twins in a family study is to disentangle possible causes of intrinsic WF correlations, none of which were found in the present study. The use of only three fingers for the composite FA marker was risky, though necessary for practical purpose of conducting data collection via the mail. The change to self administration for the latter portions of the sample also caused concerns. However, this was deemed the best hope for recruiting sufficient numbers of subjects. Ultimately the data showed that the timed SLEs and the untimed and score-adjusted SLEs were psychometrically equivalent.

The small sample size also causes interpretive problems. Although Jensen's approach compares each of the WF and BF correlations independently with respect to the null hypothesis, the comparison of these correlations with each other in the present study yielded no significant difference for FA and intelligence. Thus, the present results and interpretation should be considered tentative, subject to research with larger samples adequate for testing these comparisons.

The possibility that an environmental or developmental influence on the correlation between FA and intelligence exists in addition to the extrinsic correlation likely due to cross-assortative mating. If this intrinsic component were substantially weaker than the extrinsic one, the N in the present study would not have been sufficient to detect it. The results clearly indicate that an extrinsic influence, probably cross-assortative mating, affects the observed association between FA and intelligence. However, the sample size is not sufficient to rule out the existence of an additional but weaker environmental component.

It is again noted that the exploratory analyses should be interpreted with caution. The results of the MZ twin analyses are consistent with the conclusion that cross-assortative mating for FA and intelligence occurs. The results of the sibling Social Group/Dating Questionnaire analysis do raise significant new issues. The results suggest the possibility that several characteristics that have previously been associated with or that seem to be consistent with the complex of traits and characteristics associated with FA, such as physical attractiveness, athletic ability, leadership capacity, and dating behavior may not be conditioned directly by developmental instability, manifested as FA, but rather may be associated as a result of non-random mating for a broad array of characteristics including these. The evidence presented here is not alone sufficient to conclude cross-assortative mating does account for these associations, but it certainly highlights the need for research into such matters.

A final caution concerns interpretation of the major finding suggesting cross-assortative mating for FA and intelligence. This result means merely that FA and intelligence assort positively within mated pairs. This does not mean that FA and intelligence are necessarily the direct objects of mate preferences or choices. It is perfectly reasonable to consider the possibility that some characteristics associated with FA, for example masculinization of secondary facial characteristics, are the characteristics that are preferred by prospective mates, while FA itself is not directly preferred, but is indirectly selected as a result of its relationship with the preferred trait. This would result in cross-assortment for FA and other preferred traits, even though low-FA is not directly preferred or selected. Much of the recent work on human FA has investigated some of the physical characteristics associated with FA, and over the next several years some of these relationships should begin to be understood.

General discussion

The methodological advances in FA measurement in the present study are not inconsequential and should benefit future researchers with regard to improving the reliability of FA measurement. But, the more significant result of this study from a theoretical standpoint concerns the apparent role cross-assortative mating plays in the observed relationship between FA and intelligence.

As discussed previously, there have been relatively few published studies of cross-assortative mating for psychological or biological traits. The evidence that does exist however in the psychological and sociological literature indicates that cross-assortative mating does occur for some traits such as height and intelligence, and physical attractiveness (in females) and socioeconomic status (in males). The evidence for assortative mating on single traits is much more substantial; individuals do positively assort across a wide range of psychological, attitudinal, behavioral and anthropometric variables. The results of the present study add to this body of research and point to the need for a more studied approach to the issue of mate choice. Much more evidence exists with respect to mate preferences. There are certain characteristics that are desired in prospective mates by both sexes across cultures (Buss, 1994). Further, there are reliable cross-cultural sex differences in mate preferences as well that might be expected to lead to cross assortment resulting from individuals varying with respect to these respective traits positively assorting on the traits (Buss, 1994). To the extent that this process does occur and that the traits involved are heritable, the result would be a population stratified by some number of traits according to their relative desirability in prospective mates.

In the Terman Gifted Studies (Terman and Oden, 1959) gifted students (IQ at least 140) in California were found to be more well adjusted socially, more physically attractive, more mature and taller, among several other positive characteristics, than their classmates. For some, such as height, but not all of these characteristics, the gifted students' non-gifted siblings were found not to differ from their gifted siblings, suggesting the influence of positive cross-assortment for some traits among this extreme segment of the population. Much research in this neglected domain is called for, since the consequences for psychological research are significant.

The existence of positive cross-assortment on socially relevant traits would necessitate a reevaluation of much previous psychological research into factors influencing various socially or individually relevant outcomes. Research into behavioral and biological correlates of such outcomes as socioeconomic status, salary, occupational attainment, and occupational advancement would have to account for multicollinearity between predictor variables such as intelligence, height and physical attractiveness. In order to allow future researchers to properly account and control for such variables, a large program of research into the extent of such variables' associations in the population and the causes of such associations is required.

In a meta-analysis of attractiveness research by Langlois et al. (2000) it was found that attractive individuals are rated by others as relatively more socially adept, healthier and intelligent than the generality. Furthermore, behavioral analyses confirmed many of the perceived advantages enjoyed by attractive individuals. Perhaps the advantages enjoyed by attractive individuals do not merely reflect halo effects or other such rating biases, but rather reflect a general pattern of correlated traits, created in part by positive cross-assortment in the population on a variety of socially meaningful heritable traits. It may be reasonable in light of the inferences that can be made from the existing literature on mate preferences and mate choices, and from the empirical evidence for cross-assortative mating for at least several traits, to propose a general theory of social stratification based upon patterns of mating and reproduction. The specific details concerning which traits are subject to such influences, the extent of such influences and their consequences will be defined by future research.

Appendix A

Biographical Information

Subject ID:______________

Date of Birth: ______________________

Marital Status: _____________________ (if married, date of marriage ___________________)

Ethnicity: ______________________

You and your brother with whom you are participating in this experiment are: (check one)

______ Half-siblings

______ Full-siblings (non-twins)

______ Dizygotic twins (fraternal)

_______ Monozygotic twins (identical)

_______ Twins (uncertain whether fraternal or identical)

Appendix B

Social group/Dating Questionnaire

Put a check in the appropriate space provided for each question. If the answer for a particular question is that you and your brother are equal, please leave the answer blank. However, if you believe there is a difference, regardless of the degree of difference, please check an answer.

1. In social situations, who is more of a natural leader?

_____I am _____ My brother is

2. Who has an easier time making new friends?

_____ I do _____ My brother does

3. Which of you can more easily get a date (if one or both of you are in a committed relationship, answer the question based upon when you were single)?

_______ I can _____ My brother can

4. Who is a better athlete?

_____I am _____ My brother is

5. Who is more physically attractive?

_____ I am _____ My brother is

6. Who is more likely to get into a fistfight?

_____I am _____ My brother is

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